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ABSTRACT

Activities in this packet were developed in reference to research conducted at the U.S. Environmental Protection Agency's Mid-Continent Ecology Division in Duluth, Minnesota (MED-D). The research helps us better understand the effects of pollutants on freshwater systems such as lakes, rivers, and streams and determines how we can best keep these systems healthy. These activities are designed primarily for students in grades 4-6. They address a spectrum of freshwater research efforts ranging from the methods used in collecting samples to ecosystem-level studies. An important aspect of these activities is the involvement of students and the ease of use by teachers. Each activity can be used as a stand-alone activity or presented as part of a sequence. It is hoped that these activities will give students a greater understanding and appreciation of freshwater systems as plant and animal habitats. The package includes 16 activities organized under four topics: (1) Water Facts and Usage; (2) Ecosystems; (3) Water Pollution; and (4) Collecting, Sampling, and Keeping Aquatic Organisms. (Author/SOE)

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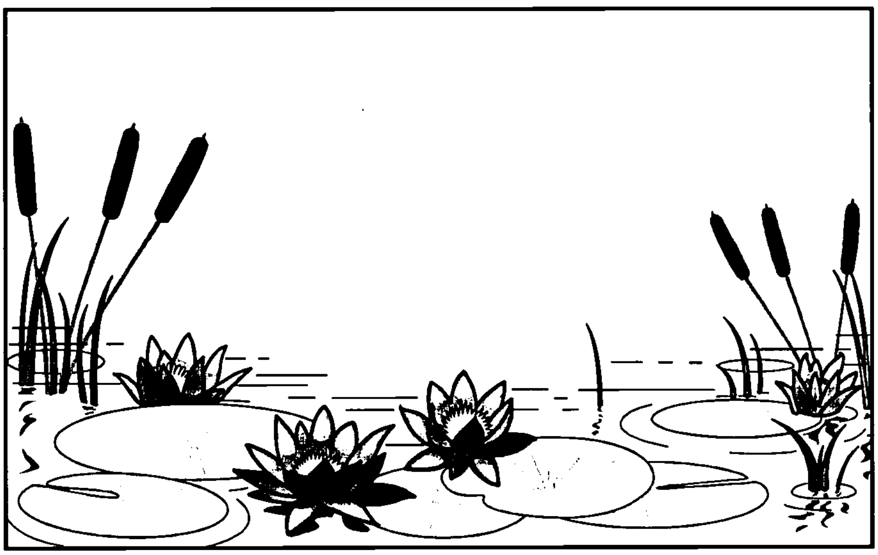

World of Fresh Water

by

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Foreword

The activities in this packet have been developed in reference to research conducted at the U.S. Environmental Protection Agency's Mid-Continent Ecology Division in Duluth, Minnesota (MED-D). The research conducted at this laboratory helps us better understand the effects of pollutants on freshwater systems (such as lakes, rivers, and streams) and determines how we can best keep these systems healthy.

These activities are designed primarily for students in grades 4-6, though most are adaptable to older age groups at the discretion of the teacher. They address a spectrum of freshwater research efforts ranging from the methods used in collecting samples to ecosystem-level studies. An important aspect of these activities is involvement of students and ease of use by teachers. Each activity can be as basic or detailed as the teacher wishes. Each can be used as a stand-alone activity or be presented as part of a sequence. Materials are generally inexpensive and easy to find. All activities presented are intended as educational resources for use with existing curricula or to be used by teachers in developing new ones.

As with all scientific experiments, you should have a specific set of SAFETY INSTRUCTIONS for each activity. We have included "Safety Notes" to call attention to procedures where particular care should be taken. In general, we urge caution when you work with chemicals and glassware, or in activities which involve student participation and movement. When using chemicals, follow the directions and safety procedures specified on the label by the manufacturer or specified by the supply house. We suggest that the teacher carry out the experiment privately before presenting it to the class.

Our goal in developing these activities was to make them "hands-on" for students and "user friendly" for teachers. We hope that you and your students enjoy and learn from the activities contained in this packet. It is our hope that they will give students a greater understanding and appreciation of freshwater systems as plant and animal habitat.

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Acknowledgments

The authors wish to acknowledge contributions of a number of people to this manuscript. Names are listed by categories relative to the roles of their contributions and alphabetized for ease of reference.

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Chapter 1
Water Facts and Usage

Earth has been called the "water planet" with good reason; water covers 75% of the globe. However, water does not restrict itself to the surface of the planet. It also filters through the crust of the Earth and floats in the atmosphere, in vapor form, as clouds. Earth is the only planet in our solar system with water on the surface, underground, and in the atmosphere.

Water obeys the laws of gravity. It seeks the lowest level possible, finding its way into any space into which it is able to flow. Through its constant wanderings, water is one of the major forces that shapes our planet.

It was the arrival of water on our planet that allowed life to develop. Without water, there would be no life, and water quality has a great influence on the quality of life.

Water appears to occur in such abundance that it seems we have an unlimited supply available for human use. However, the amount of available fresh water is comparatively tiny; only about of 1% of the world's water. This activity will help students understand that only small amounts of water are available, and it will show them how much we depend on fresh water in our daily lives.

Taster's Choice

Overview: Students sample various waters to select the best for drinking.

Objective: To understand the importance of quality, fresh water in our lives.

Materials for 28 students: 77 small paper cups; 5 clean, empty 2-liter pop bottles plus a 2-liter bottle of carbonated water; tap water; 1 Tbsp. each salt, sugar, and lemon juice; 1 tsp. alum; 7 data sheets.

Teaching time: 30-45 minutes.

NOTE: This activity is planned for 28 students working in 7 groups of 4. It may be easily modified for more or fewer students.

Teacher Instructions

A. Before the lesson:

1. Obtain supplies. Alum is usually available from the spice section of grocery stores. Remove the label from the carbonated water bottle.

2. Label the 2-liter bottles 1 through 6, with (1) being the carbonated water. Make up the other 5 2-liter water samples as follows; (2) plain tap water, (3) tap water plus 1 tablespoon salt, (4) tap water plus 1 tablespoon sugar, (5) tap water plus 1 tablespoon lemon juice, and (6) tap water plus 1 teaspoon of alum.

3. Label 42 small paper cups with numbers 1-6. There will be 7 number 1's, 7 number 2's, etc. Students may do this as part of the activity if you wish.

4. Each of the 7 stations will require: a set of 6 cups labeled 1-6; 4 drinking cups; 1 "spit" cup; 1 Taster's Choice data sheet; pencil.

B. With the students:

1. Break into 7 groups of 4 students. Introduce the activity as an investigation into the importance of "clean" water for drinking. Explain that none of the samples are dangerous to swallow, although some will certainly taste better than others.

   Safety note: Warn students that tasting is not a good way to find out whether water is safe for drinking. In this activity, the flavored waters provided are safe to taste.

   Students who do not wish to swallow their samples can use the "spit" cup. It is important that the tasting cups be emptied before the next round begins so each round starts with

an unmixed water sample.

2. Six students can distribute the appropriate water samples to the numbered cups at each station. Each student will use his/her paper cup to taste each of the 6 samples. After each taste, a student recorder should write down the reactions to the sample on the student observation sheet provided. You may choose to begin with the group tasting one water at a time to make sure students do not taste too fast for the recorder.

3. Summarize results on the board, in chart form, with student recorders supplying group opinions. Discuss with the class the results of their observations. Ask the students to choose which one of the six water samples would they prefer to be coming out of their taps at home and in school. Students usually prefer the plain tap water.

4. Tell the students that the tap water they use every day is an example of fresh water. Ask them to come up with a definition of fresh water and write that definition down on their observation sheets. A typical definition would be that fresh water is not salty.

5. Using the board, brainstorm how people use water. Let the students pick one of these to make a poster of themselves, their families, or their friends using water in one of the ways. They may wish to use their definition of fresh water as a starting point for a slogan.

7. Clean up: Liquids can be safely poured down the sink.

GROUP NAME ______________________

SOLUTION NUMBER	WRITE HOW EACH SAMPLE TASTED
SOLUTION #1	
SOLUTION #2	
SOLUTION #3	
SOLUTION #4	
SOLUTION #5	
SOLUTION #6	

My definition of fresh water is:

____

____

____

Remember: do not taste unknown water samples except these provided by the teacher!

Figure 1-1. Data sheet, taster's choice results.

Our Tubs Runneth Over

(Adapted from Environment on File, 1991)

Overview: Students estimate their personal water use and compare this to U.S. averages, as well as compare U.S. water use to other countries.

Objective: To examine the use of fresh water in the U.S.

Materials For 28 Students: Student worksheet (Figure 1-2); 7 sets of paper water-use cards (Figure 1-3); 7 1-cup measures; 6 large containers, such as garbage cans; water supply.

Teaching Time: Approximately 45-50 minutes.

Note: This activity is planned for 28 students working in 7 groups of 4. It may be cut down or expanded as needed.

Teacher Instructions

A. Before the lesson:

1. Make 7 copies of the water use cards sheet, and cut them to make 7 sets of "cards."

B. With the students:

1. Organize groups of 4 students. Brainstorm the many ways we use fresh water. See if students can figure out the 6 main ways we use water at home (see next page). Give each group cards listing each of the 6 different categories. Their job is to place the cards on their desk or table in order of the largest amount to smallest amount of water used by their families.

2. On the group's worksheet, have them estimate how many cups of water in each category they use each day.

3. According to Environment on File, each person in the U.S. uses an average of 6,320 liters of water every day. If you would like the students to convert this to cups, multiply by 4.23 cups per liter (26,734 cups). The next highest water user is Canada where usage is 4,130 liters of water per person, per day. These figures include water used in industry and agriculture. It is added on to the personal totals because, as citizens of the United States, we all benefit from the use of water by these industries. However, only about 12% of this per-person total is used by individuals at home. Multiplying 6,320 liters by 12% gives us a daily per-person water use of 758 liters per day at home or about 3,206 cups per person, per day.

4. Knowing this, and estimates for the percent of water use by different categories, we can figure out about how many cups of water the average American uses for each of these activities each day (Table 1-1). Ask the students to compare the values that they predicted in their groups to professional estimates for each of the water uses. Most people greatly underestimate their water use.

Table 1-1. Water use by average American.

Water Use	Cups	Percent of Total Use
Washing/showering	865	27
Toilet flushing	769	24
Running washing machine	545	17
Doing dishes	449	14
Cooking/drinking	321	10
Gardening/washing cars	256	8

5. To give the students an idea of how much water this actually is, groups can fill garbage cans for each category by counting cups of water into them. The 769 cups of water for toilet flushing will nearly fill a 50-gallon garbage can. If you have a non-slippery outdoor area, you may choose to fill the cans by setting up a relay race.

6. Water use varies a great deal by country (Table 1-2). Ask the students to guess the top 10 countries for water usage, and rank them on their worksheet with the highest on top. Discuss the reasons why the United States uses so much water compared to other nations (habits, irrigated agriculture, technology to withdraw and deliver water, and industry).

Table 1-2. Water use by country.

Country	Amount of Water Used Daily (liters)
United States	6,320
Canada	4,130
Australia	3,320
Italy	2,960
Netherlands	2,730
Spain	2,650
Japan	2,530
Belgium	2,510
Finland	2,120
Germany	1,870
France	1,370
Norway	1,340
Sweden	1,310
New Zealand	1,050
United Kingdom	700
Denmark	650
Switzerland	290

7. You may want the students to find these countries on the map and write in how many liters of water each person uses per day in each country. Does this give some clues as to what types of countries are the big water users?

NAME___________________________

How many cups of water/day do you use while:

1. Washing/showering ___________
2. Toilet flushing ___________
3. Running washing machine ___________
4. Doing dishes ___________
5. Cooking/drinking ___________
6. Gardening/washing cars ___________

Usage of Water by Country (greatest usage on top)

RANK	ESTIMATE	ACTUAL
1.	___________	___________
2.	___________	___________
3.	___________	___________
4.	___________	___________
5.	___________	___________
6.	___________	___________
7.	___________	___________
8.	___________	___________
9.	___________	___________
10.	___________	___________

Figure 1-2. Data sheet, student water use.

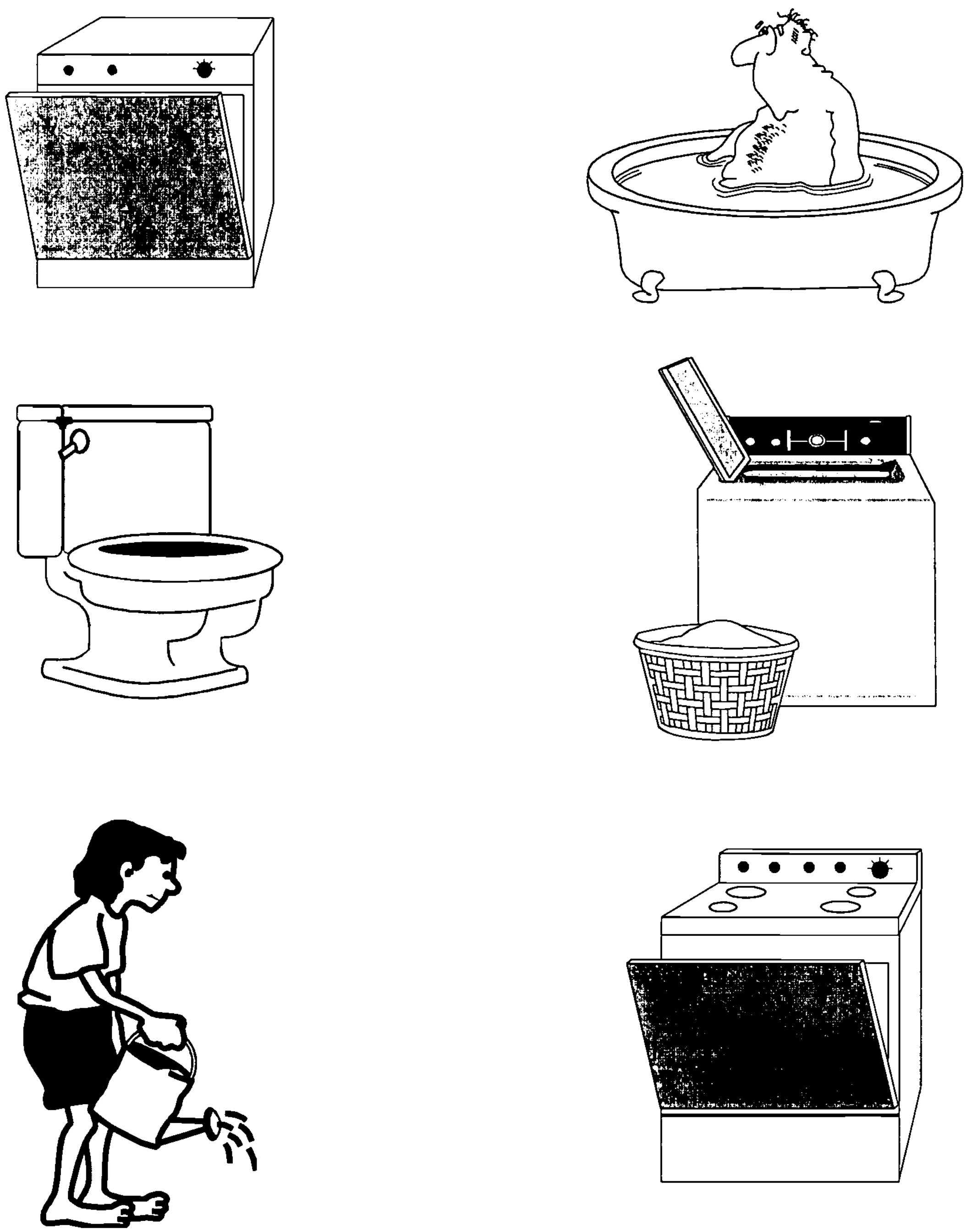


Figure 1-3. Water use cards.

Water, Water, Everywhere?

(Adapted from Project Stewardship Minnesota)

Overview: Students see what proportion of the world's water is fresh water.

Objective: To demonstrate the relatively small amount of fresh water available for our use.

Materials for Demonstration: 9 clear, 1,000-ml containers such as mayonnaise jars; labeling pen; masking tape; graduated cylinder (if available); tablespoon; medicine dropper or pipet; water supply.

Teaching Time: 15-25 minutes.

Note: This activity is described here as a demonstration, but it can be adapted to be done by students.

Teacher Instructions

A. Before the lesson:

1. Label 8 jars with masking tape and pen: Ocean, Icecaps/glaciers, Groundwater, Saline lakes, Freshwater lakes, Soil moisture, Atmosphere, Rivers. Label one jar on one side "All the Water in the World" and on the other side, "Currently Useable Fresh Water."

B. With the students:

1. Remind the students of their definition of fresh water, if they have done the Taster's Choice activity, or use a working definition that fresh water is water that is not salty.

2. Show the class the "All the Water in the World" jar, and ask them to pretend that all of the Earth's water will fit into this jar. Fill it with 1,000 ml water.

3. Using the World's Water Supply (Table 1-3), measure out the following amounts and pour into the appropriate container:

Table 1-3. World's water supply relative to 1-liter total.

Source	Amount (ml)	Percent of Total
Oceans	973 or 4 cups	97 (approximately)
Icecaps/glaciers	21 or 1.5 tablespoons	2.1
Groundwater (down to 13,000 ft)	6.1 or .5 tablespoon	0.6
Saline lakes	0.08 or 2 drops	0.1
Freshwater lakes	0.09 or 2 drops	0.1
Soil moisture	0.05 or 1 drop	0.005
Atmosphere	0.01 or 1/5 drop	0.001
Rivers	not enough to be measured	0.0001

At this point, the original jar should be empty.

4. Ask the students to offer ideas about which of these are currently available as inexpensive sources of useable fresh water.

5. Turn the original jar around to show the "Currently Useable Fresh water" side. Add back the amounts of water that are currently useable by industry, including agriculture:

    of the groundwater (the other is too salty),
    nearly all of the freshwater lakes,
    nearly all of the soil moisture,
    nearly all of the river water.

    Ask the students how much of this industrially useable water they think would be fit for drinking as it is. There are no accurate figures for this, but it could be about half.

6. Discuss with the class all of the uses that we have for water, and then compare it to the relatively small amount of fresh water that we actually have available.

Chapter 2
Ecosystems

Our environment contains natural associations called "ecosystems." Examples include ponds, bogs, and forests. Some may be very small, like the ecosystem in a fallen log. Some may be very large, like Lake Superior. In this section, we will look at ponds, wetlands, and miniature freshwater ecosystems.

Each ecosystem has its own source(s) of energy, nonliving components, and living components. The source of energy is usually the sun. Nonliving components include air, water, and minerals. Living components include plants, animals, bacteria, and fungi. A proper balance of these components allows the system to stay healthy.

In addition to understanding how ecosystems depend on a proper balance of components, we need to begin to understand the role of humans within the ecosystem. People are a part of many aquatic ecosystems, and what we choose to do as part of our everyday lives affects these ecosystems. Too often we view ourselves as outsiders to natural ecosystems when nothing could be further from the truth. We need to include ourselves so we recognize our connection to, and reliance on, ecosystems as well as our potential for altering them.

This section includes lessons that help students understand the importance of balanced interactions in ecosystems and the importance of each part.

Life in a Pond

Overview: Students play an active outdoor game, taking the roles of Daphnia and dragonfly nymphs, which are two members of the pond ecosystem.

Objective: To simulate food-chain interactions through student play.

Materials for 1 Classroom: "Members of the Pond" information sheet; several small boxes; either 1 large bag each of white and colored popcorn or slips of paper; materials to make name tags for predator/prey; cones or string; whistle.

Teaching Time: 45-60 minutes.

Note: This activity is planned for an entire classroom to play.

Teacher Instructions

A. Background information:

A food chain is an interaction of plants and animals in their quest for survival. A food chain starts with a plant that is able to use energy from the sun, and nutrients from its surroundings, to make food. Small organisms can eat the plant for food. In turn, the small organisms become food for larger animals. They may then become food for even larger animals and so on up the food chain. The animals that are eaten in a food chain are called prey; the animals that eat other animals for food are called predators. A food chain can be as simple as three organisms or very complex with many different predator/prey interactions. When an organism in the food chain dies, it becomes nutrients for the plants at the base of the food chain. In most healthy food chains, there is a mix of different organisms on each level of the food chain - many organisms at the base of the food chain and fewer at the top. The following game is designed to help students understand this relationship as it occurs in a freshwater pond.

B. Before the lesson:

1. Select and inspect a playing area. It should be a large open area such as a gym or a field. Mark off a large portion of this area as the "pond" using cones or string.

2. Decide what you want to use for "green algae" and "blue-green algae." One choice is white popped corn for "green algae" and colored popped corn for "blue-green algae" or slips of paper saying "algae" and "blue-green algae." An advantage of the popcorn is that students can eat it as long as proper hygiene is observed.

C. With the students:

1. Using the background information provided, review food chains, and explain that students will have a chance to be predators or prey. Use the "Members of the Pond" information (p. 2-5) to introduce the organisms and learn their roles.

2. Show the students the popcorn or slips of paper representing green and blue-green algae, and emphasize that the blue-green algae is not a good food source for Daphnia compared with green algae. Signify one-third of the class as dragonfly nymphs (the predators) and two thirds of the class as Daphnia (the prey). Each student should make a name tag telling what organism they are. Cover the rules of the game as listed below.

3. To play the game:

   a. Place several boxes of mixed green and blue-green "algae" around the playing field.

   b. The game begins with dragonfly nymphs on one side of the playing field and the Daphnia on the opposite side of the field. The object of the game is for the Daphnia to reach the opposite side of the pond without being "eaten" by a dragonfly.

   c. Daphnia "eat" by taking one kernel of popcorn or one slip of paper. Dragonfly nymphs "eat" by tagging Daphnia.

   d. To move across the field, the predators and prey must follow some "laws of nature." They can move only when the whistle blows to start a round, and they must move only a certain number of steps each time. The end of a round will be marked with two blasts from the whistle. When they die or are eaten, they must move to the edge of the pond until a new generation is born.

   e. When the whistle is blown, each Daphnia can take ten large steps. If they reach food, they will take one kernel of popcorn (or one slip of paper). If they eat a green alga, on their next turn they will be allowed ten more steps. If they eat a blue-green alga, they will be allowed only five steps. If they reach no food, they are allowed two steps.

   f. Meanwhile, when the whistle is blown, the dragonflies are also allowed ten steps. If they eat a Daphnia (by tagging the person), they will be able to move ten steps in the next round. If they reach no food, they will still be able to move ten steps in the next round because larger organisms can go a longer time without food.

   g.When everyone understands the rules, start the game with a whistle. After everyone has moved and eaten (or not eaten), blow the whistle twice to stop the action. Any organism, which does not find food two rounds in a row, will sit out for one round if a Daphnia and two rounds if a dragonfly nymph (Daphnia have a shorter regeneration time than dragonfly nymphs). After that, they will return to the side where they began and start again when the whistle is blown for the next round.

h. Continue for a third and fourth round. When a Daphnia makes it across, the game can be concluded, or the Daphnia can immediately return to the other side of the pond.

   Safety note: The students have to be careful when "tagging." If the students eat the popcorn, they need to be careful while eating to avoid choking.

4. After the game, discuss the interactions between predator and prey, and discuss the results of the game in relation to pond food chains. Typical observations:

   - It is easier for dragonflies to eat when there are a lot of Daphnia but difficult when they get scarce.
   - When the green algae are gone, the Daphnia are in more danger.
   - If some dragonflies "starve", the Daphnia can "catch up" somewhat in numbers.

5. Clean up: All slips of paper should be removed from the playing area. Small amounts of popcorn that remain in an outdoor play area will be eaten by birds.

Members of the Pond

Many living things in pond water are plankton (tiny plants or animals), while other organisms are larger, such as insects. In this exercise, we will look at three kinds of plankton and one example of an insect.

Green Algae

These phytoplankton (plant plankton) take nutrients from water and energy from sunlight to make sugar. This is valuable food for small animals. Algae are the base of our pond's food chain and also add oxygen to the water. Although they are often called plants, most phytoplankton are really protists.

Blue-green Algae

Blue-green algae (also known as cyanobacteria) also take nutrients from the water and turn it into sugar. But for some reason, blue-green algae don't "taste" as good as the other types of algae to most small animals and are not a preferred food. Blue-green algae can also be dangerous to the life of a pond. If too many nutrients get into the water (usually through some sort of pollution), the blue-green algae divide very quickly and then float to the top, forming "blooms." Blooms prevent sunlight from getting to the bottom of the pond which makes it hard for the green algae, or other plants, to survive. When they die, they rot, which uses up the oxygen that is in the water. If the bloom takes over the entire pond or lake, the other organisms in the water have a hard time surviving and will probably die. Ponds and lakes in which this occurs smell terrible.

Daphnia

These water fleas are one type of zooplankton or animal plankton. They are one of several different types of tiny animals that eat algae and serve as food for larger animals. They much prefer green algae to blue-green algae. Daphnia can be found in our pond in large numbers because they are near the base of the food chain.

Dragonfly Nymph

A dragonfly nymph is a young dragonfly. It is not a larva because it does not go through complete metamorphosis like a butterfly does. Instead, the dragonfly nymph looks a lot like an adult dragonfly without the wings. In our pond, it is a predator of Daphnia. There are also animals that will feed on the dragonfly nymph (such as the bluegill sunfish) but, for this exercise, the dragonfly will have no predators.

Creating a Classroom Microcosm

Overview: Students start and maintain mini ponds (microcosms) in a jar.

Objective: To grow several different microcosms from different ponds or from different areas of the same pond.

Materials for 28 Students: 7 quart-sized glass or clear plastic jars (such as canning jars); 7 plastic or metal buckets; hand lenses; microscopes if possible; pond site(s).

Teaching Time: 30-50 minutes of one class period then a few minutes of several class periods thereafter.

Note: This activity is planned for 28 students working in 7 groups of 4. It may be easily modified for more or fewer students.

Teacher Instructions

A. Background information:

There are a variety of plants, animals, and nutrients in every living system. Plants use nutrients, and energy from the sun, to make food that animals can use. When plants and animals die, or when animals eliminate wastes, nutrients are released that plants can use again as food. Usually these systems are complex and have many members. You can observe a relatively simple system by making a microcosm (tiny world). A microcosm is an interacting system of small organisms in an enclosed space. Microcosms are used by scientists who need contained ecosystems in which to test the effects of chemicals or introduced species. In this lesson, students will make microcosms to observe in the classroom.

B. Before the lesson:

1. You must first find a pond from which students can safely collect samples. Dried ponds work well because they contain eggs of many small organisms that "hibernated" when the pond went dry. Add pond water or aged tap water to the mud to allow the eggs to hatch. If you only have wet ponds to choose from, you will need to devise a way to get a sample of the pond bottom. Choices include wading with shoes or boots, using a shovel or rake, or making the bottom scraper from the "Aquatic Samplers" activity in this guide.

C. With the students:

1. Review the concept of an ecosystem, using the background information provided, and explain that each group of 4 students will be able to make a small aquatic ecosystem in a jar - a microcosm. They will use plastic buckets for collecting and carrying mud from the pond and then transfer mud and pond water to their microcosm.

2. At the pond site, each group should collect about 1 cup of mud and 1 liter of water. Instruct each group of students to collect their samples from different areas of the pond and at different depths, if possible. Each group should record the location from which their sample was taken.

   Safety note: Pond sampling should always be done with an eye to safety. The greatest hazard is often litter such as glass on the bottom. For that reason, make sure the students wear shoes. The completed microcosms are somewhat heavy and may be slippery. Students should fill the microcosms where they will stay so they do not need to carry them around the classroom.

3. In the classroom, groups should add 1-2" of mud to the microcosm jars, then add pond water to near the top. Cover the jars loosely with plastic or lids. Punch holes in the top so that air can get in and out of the jar. Store the jars in a lit area - but not in direct sunlight. Direct sunlight will cause the microcosm to heat up, and the organisms inside will die.

4. Observe the microcosms daily with hand lenses, and have the students record their observations. Samples of the microcosms can be removed and examined under microscopes. Talk about differences in the types of organisms present (such as one sample with no visible organisms versus others with many) or differences in the appearance of the jars (such as greenish versus clear water) between the different sites. This information can be graphed by site. For example, make a bar graph with the vertical axis the number of organisms and each bar referring to a different microcosm. You may want to talk about food chains after observing the microcosms for a period of time.

5. Clean up: The microcosms should be returned to the pond from which they came. This can be part of the activity. If they came from a dried pond, they can be returned to similar shallow ponds in the area.

A Wetland Ecosystem

Overview: Students take on roles of wetland organisms and create a web with string that connects them.

Objective: To demonstrate the importance of all parts of an ecosystem using a wetland as a model.

Materials for 28 Students: Photos, drawings, or name signs of specimens representing different members of a wetland ecosystem; a large ball of yarn or string.

Teaching Time: 45-50 minutes.

Teacher Instructions

A. Background information:

Wetlands are areas where water and land meet, forming a boundary between water ecosystems and land ecosystems. Wetlands have a diversity of plants and animals all their own. In recent years, much attention has been given to the preservation of wetlands because many of them are being destroyed to make way for human habitation or other developments. There are many different types of wetlands, but this lesson uses a "generic" simplified cast of organisms that could be found in wetlands anywhere in the United States. For more information, see the book Wetlands listed in the Appendix B.

B. Before the lesson:

1. Decide how to represent the members of a wetland ecosystem. Photos work well, but you can also make drawings or name signs to depict each of the organisms.

C. With the students:

1. Begin the lesson by defining wetlands using the background information provided.

2. Go over the "Parts of the Wetland" included with this activity. This is a partial list of living and nonliving components that might be found in a wetland. As you go through the list, hold up the representation (photos, drawings, or name signs) of each of the components.

3. Have the students sit in a circle with the representative wetland components in the middle. Tell the students that they will become the wetland by choosing to be different parts of the wetland. Include a sample of water and a representation of the sun in the collection.

4. Allow each student to choose to be one part of the wetland.

5. After all students have made their choices, take a look at your wetland. The students most often choose the organisms that they are most familiar with or those that seem to them to be the most important (the bigger ones). Ask for a show of hands as to who chose what, starting with water. If no one chose water, then you have no wetland, and you need to place all of the components back into the center and choose again - everyone must choose a different part of the wetland.

6. Once you have water, ask again for a show of hands as to who chose which component. Start again with water. Emphasize how important water is to everything else in the wetland. Next, ask for those who chose to be algae or other aquatic plants. If no one (or very few) chose plants, you need to start over again because plants are the base of the food chain and without plants, the animals could not use the energy from the sun to make food (as the plants can), and you have no wetland.

7. Repeat this exercise until you get a variety of water, plants, and animals. Discuss the importance of having a variety of plants and animals within the ecosystem. Ask the students which part of the ecosystem was the most important - the large, visible animals and plants or those that we rarely think of as being animals and plants. Or are they <u>all</u> important?

8. Using a large ball of yarn, start with water and sunlight and ask what members of the wetland use these things. Connect students with yarn as they demonstrate relationships. Cut the yarn whenever it becomes cumbersome. Eventually it should be clear that all members of the ecosystem are connected. Try tugging on one link of the web and seeing how many students can feel it. If each student who feels the tug pulls on the lines he or she is holding, the original tug will ripple through the whole community just as wetland disturbances affect many organisms.

Parts of the Wetland

1. Sunlight

2. Water: 5 to 7 small jars.

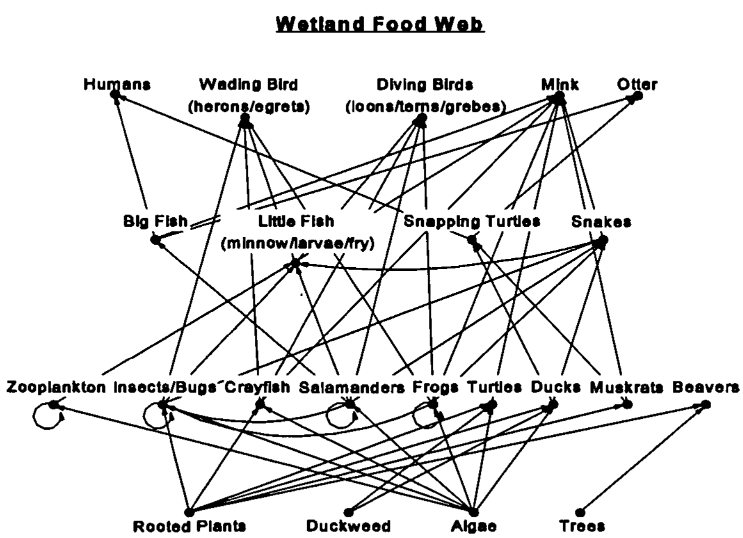
3. Plants:
   - 2 to 4 rooted plants (cattails or bulrushes).
   - 5 to 7 samples of algae.

4. Plant Eaters:
   - 2 to 3 zooplankton (microscopic animals)
   - 2 to 3 turtles
   - 2 to 3 ducks
   - 2 to 3 frogs

5. Medium-sized Animals:
   - 1 to 2 snakes
   - 1 to 2 snapping turtles
   - 1 to 2 fish

6. Predator: Mink

Figure 2-1. Wetlands food web.



Chapter 3
Water Pollution

In the past, scientists were concerned about visible forms of water pollution. Large quantities of raw sewage and hazardous wastes were dumped into our fresh water. Increased amounts of pollution in the water caused the water to become discolored and smelly and changed the water until some of it was dangerous to life. In extreme cases, fish died in large numbers.

These obvious signs created much concern for environmentalists. Research studies showed the effects of pollution not only on fish, but also on various species throughout the food chain. In 1964, Rachel Carson reported much of this in a book called Silent Spring. This book attracted much public attention and pointed out the magnitude of the problem. People realized the need for action and figured out what needed to be done. Agencies were formed, rules were written and enforced, and water quality improved.

However, water pollution problems did not disappear. The water pollution problems we have today are terribly complex and difficult to study. These days, most water pollution is invisible. In addition to oil spills and toxic leaks, we must deal with less obvious pollutants. Thousands of chemicals are present in the water and sediments - some are toxic, some build up in the food chain and become toxic, and some are toxic only when combined with other chemicals. Many are present in such small amounts that they are hard to measure. Scientists must conduct experiments to test the nature of each potentially harmful chemical so standards can be set. This task is both time consuming and costly, but failure to address water pollution problems could result in disaster because the health of our planet, and all of us that live here, depends on the quality of our water. In this section, the lessons address the complexities of today's water pollution problems.

Dilution: A Pollution Solution?

Overview: This quick demonstration involves diluting a beaker of colored water with clear water.

Objective: To show that dilution takes a very long time and may not be a good solution to a water pollution problem.

Materials for Demonstration: 1 empty aquarium or other large clear container; 2 500-ml beakers or mayonnaise jars; tap water; red food color.

Teaching Time: 40 minutes.

Teacher Instructions

A. Background information:

Lakes have many sources of "new" water, including runoff from surrounding land, groundwater, and rainfall on the surface of the lake. This "new" water gradually replaces the existing lake water, which may evaporate or be discharged through an outlet. The amount of time for enough "new" water to replace all the lake's water is called retention time. It is also called renewal time or even flush rate. It is a useful concept because it gives an idea of how often the lake water is "renewed." The amount of time varies greatly - from 9 years for Lake Erie, to nearly 200 years for Lake Superior.

Sometimes people think of this as how much time would be needed to "flush" the lake of pollutants. There are two important considerations here: where does the polluted water go (does it go to pollute a river, or another lake?) and whether one renewal time would actually flush the lake clean. This exercise addresses both of these concerns.

B. With the students:

1. Fill one of the beakers or jars with tap water, and stir in a few drops of food color so that it is bright red. Explain to the students that the red food color could represent a pollutant that is in a nearby lake. It is nice to think that clean rainwater could eventually dilute the pollutant so the lake would be clean again. Ask the students how long they think this might take (answers will vary).

2. Try one complete renewal of water. To do this, fill the second beaker with tap water. This will represent the amount of rain and other new water that would completely replace the existing lake water. Have a student hold the "polluted" beaker over the aquarium, while you gradually pour clean tap water into the "polluted" beaker. The waters will mix and overflow into the aquarium, and it will be evident that much of the "pollutant" is gone from the lake.

3. Ask if the red color can still be seen in the lake. If it can, you have demonstrated that more than one retention time is needed to flush pollutants from your imaginary lake. Try a second complete renewal, again pouring the new water on top of the lake. It will typically take 3 or 4 replacements before you can no longer see the "pollutant." Ask the students if they feel sure the pollutant is completely gone once they can no longer see it. Actually, our eyes are rather unreliable at detecting pollution - small amounts of pollutants tend to be invisible to us.

4. Introduce the concept of retention time and that it varies from lake to lake. Typical retention times for medium-sized lakes in the Midwest is on the order of 3-10 years. Lake Superior takes much longer. Calculate the number of generations it would take for Lake Superior to renew twice (200 x 2 divided by 25 = 16 generations). That is why we must protect our lakes now to prevent pollution that will be with us for so long.

5. Now examine the water that overflowed from the "polluted" lake. Did the pollutant go "away"? Discuss what away means. It is a key problem in pollution control that we often simply move pollutants around rather than solve the problem.

6. Another aspect of the dilution "solution" is to consider the source of renewal water. If this water is polluted, the lake may never be clean again.

A Healthy Glow

Overview: Students perform an experiment dealing with the effect of a pollutant (vinegar) on a small aquatic organism called Daphnia magna.

Objective: To see how a pollutant can affect the eating activities of a living organism.

Materials for 28 Students: 210 Daphnia; 1 gram sugar-dye compound (4-methyl-umbelliferyl-beta-d-galactoside); 3 ml vinegar; lake water or aged tap water; ultraviolet (UV) light source (a black light works best); viewing box for black light; 42 30-ml beakers or baby food jars; 7 droppers or pipets with wide openings; graduated cylinders (100 ml, 50 ml, 5 ml); a 1-liter bottle.

If students prepare their own dilution series, you will need 21 graduated cylinders (7 each 100 ml, 50 ml, 5 ml). If you prepare the solutions for students, you will need 1 of each size graduated cylinder.

Teaching Time: Approximately two 50-minute class periods.

Note: This activity is planned for 28 students working in 7 groups of 4. It may be easily modified for more or fewer students. It may also be a demonstration.

Teacher Instructions

A. Background information:

A toxicity test is one type of experiment used by scientists studying water pollution. A toxicity test makes use of live organisms to assess safe and unsafe levels of toxic chemicals in the water. The purpose of the experiment is to determine what amount of the pollutant in the water will harm an organism and in what way. This is an important issue for researchers who must give information to those who write regulations that affect business and industry.

The organism we will use is the water flea Daphnia magna. They are near the base of the food chain, eating small plants for food and being eaten by larger animals. The health of this little animal can determine the health of the entire food chain. Different types of water fleas are often used in these types of experiments because they are found nearly everywhere, can be raised easily and consistently in a lab (or a classroom), and are sensitive to many pollutants.

This experiment will show how a pollutant may affect an organism. Effects of pollutants are often subtle. For example, a chemical may not kill an organism, but might deform it in some way, slow it down so it can't catch food or can't escape a predator, interfere with its ability to reproduce, or be passed on to its offspring. In this experiment, we will be looking for non-lethal effects, particularly, loss of the desire or ability to eat.

The pollutant we will use is vinegar, which is a weak acid. This is a very relevant choice to make since acid precipitation is a very real environmental problem. Straight vinegar is 5% acetic acid which would kill any Daphnia we put into it. We do not want to kill any Daphnia, but see how vinegar affects their eating habits and health.

In order to see which Daphnia are eating and which are not, we will feed them a "sugar-dye." In this compound, the sugar and the dye are connected in such a way that we cannot see the dye. But if this connection is broken, the dye glows when viewed under ultraviolet light. When the Daphnia eat the sugar-dye, they break the connection between the sugar and the dye. This makes the dye visible in the transparent bodies of the Daphnia when viewed under ultraviolet light.

B. Before the lesson:

1. Order the sugar-dye compound from a chemical supply house such as Sigma. Order Daphnia magna from a biological supply house such as Carolina. Time the shipping of this order so you can do this activity soon after the Daphnia arrive. Check to make sure the openings on the pipets are large enough for Daphnia to pass through. If necessary, you can cut plastic pipets to make a larger opening or use turkey basters.

2. Set up a safe, black-light viewing station.

   Safety note: UV light is harmful to the eyes. You can use UV light safely with a commercial viewer, or you can construct your own. The object is to limit room light and prevent students from looking directly at the UV bulb. One way to do this is to cut a window in a cardboard box and place the UV bulb below the window in such a way that the sample will be illuminated, but students cannot view the bulb. The sample can be placed on a small stand inside the box to bring it closer to the height of the window.

3. Prepare the sugar-dye solution. The sugar-dye compound will come in crystalline form. To mix the solution, get a plastic 1-liter bottle and mix 500 ml of lake water to 1 gram of crystal sugar-dye compound. Put on the cover and shake well. Shake the solution each time before you use it because the sugar-dye does not mix well with water. Label and store this in the refrigerator.

4. Prepare a vinegar solution by putting 3 ml of vinegar in a container and adding lake or aged tap water to make a total of 600 ml.

5. The next task is to prepare a series of solutions, each more dilute than the previous one. You may make this yourself ahead of time, or do it with the students. Student directions are given in the "With the Students" section. Following are directions for you to make the proper concentrations ahead of time. Take 600 ml of the vinegar solution, pour out 300 ml in a beaker or jar, and call it treatment #5. Add 300 ml of lake water to the original container and stir. Pour out 300 ml into a new jar, and this is treatment #4. Add another 300 ml of lake water to the original container and pour half out again. This is treatment #3. Continue the procedure for treatments 2 and 1.

C. With the students:

1. Introduce the idea of a toxicity test using the background information. Ask the students if they can list ways that a chemical can harm a living organism other than killing it. Show the vinegar, and introduce the idea of acidity as a pollutant.

2. Introduce Daphnia. Emphasize that we have no desire to hurt these creatures, but that there is always the possibility that individuals will be hurt or killed in handling. The small amounts of vinegar we are using are not expected to kill Daphnia but may upset them enough that they do not eat for a while. The Daphnia are expected to recover.

3. Introduce the sugar-dye using the background information.

4. Each group of 4 students should get 6 baby food jars, a supply of vinegar solution, and a supply of lake water. Label one jar "c" for control. Explain that the control jar will have no pollutant (vinegar) in it. A control is the part of an experiment that represents what would happen under normal conditions. Label the other jars "treatment 1" through "treatment 5." A treatment is a variable added to an experiment to see what effect the variable will have on the experiment. Our variable is the amount of vinegar we add to the water.

5. Now have students fill their labeled jars with different concentrations of vinegar solution. In the jar marked "c", measure out 30 ml of lake water (no vinegar solution). Now we need to add a known amount of pollutant to the water. If you have prepared the treatments ahead of time, show students the vinegar solutions, and explain how you made them. Have students transfer 30 ml of each treatment into the appropriately labeled jar.

6. If you would like the students to prepare their own dilution series, you can go through the following procedure step by step with the students.

    a. In jar #5, add 30 ml of the vinegar solution.
    b. In jar #4, add 16 ml of vinegar solution and fill to 30 ml with lake water.
    c. In jar #3, add 8 ml of vinegar solution and fill to 30 ml with lake water.
    d. In jar #2, add 4 ml of vinegar solution and fill to 30 ml with lake water.
    e. In jar #1, add 2 ml of vinegar solution and fill to 30 ml with lake water.

7. The next portion of the lesson takes 30 - 45 minutes. You can stop here, and resume the lesson within a week. The students should cover their containers.

8. In the next stage, students add 5 Daphnia to each of the 6 jars. Demonstrate how to add Daphnia to a solution as follows: take up Daphnia from a beaker in a pipet. Put the end of the pipet below the surface of the solution you are adding it to and gently squeeze the Daphnia out of the pipet. If a Daphnid is exposed to air, it will get air trapped underneath its outer covering (called a carapace) and will float on the surface. If a Daphnid floats or does not move, it has been injured during the transfer. Replace it with another Daphnid. Keep the water and container that the Daphnia were shipped in to serve as a recovery tank for them until the end of the experiment.

9. Allow Daphnia to swim in the treatments and control jars for 30 minutes. Observe. Then add approximately 10 ml of the sugar-dye solution to each of the 6 jars and let the Daphnia feed for 15 minutes.

10. Explain to the students that the sugar and the dye are connected in the water in such a way that we cannot see the dye. The Daphnia eat the sugar-dye and break the connection between the sugar and the dye, which then makes the dye visible in the transparent bodies of the Daphnia when viewed under ultra-violet light.

11. Observe the Daphnia under UV light using a commercial viewer, or by placing the UV bulb inside a box that has a window cut in it, so you can view the jars but not look directly at the bulb. Count the numbers of glowing Daphnia in each jar and note their activity. Fill out the observation sheet (Figure 3-1). After viewing and recording, remove the Daphnia from their treatments, and place them together in the container they came in.

12. Have groups experiment with ways to graph their data. One effective graph places the number not glowing on the vertical axis and uses bars for each treatment and the control.

13. Make sure it is clear to the students that the Daphnia that were glowing were those that ate the most sugar-dye compound. Why did some of the Daphnia not eat? Discuss how "sick" Daphnia can affect the health of the food chain.

14. Clean up: all used liquids may be poured down the drain. Daphnia may be retained as classroom or household pets in small aquaria (see Raising Algae and Water Fleas) or disposed of.

Group Names: ______________________________

Observation of Daphnia (include the activities of the Daphnia and the number of Daphnia glowing):

	Room Light		UV Light	
	Moving	Not Moving	Glowing	Not Glowing (or glowing more faintly than controls)
Control Jar				
Treatment 1 (mildest)				
Treatment 2				
Treatment 3				
Treatment 4				
Treatment 5 (strongest)				

Figure 3-1. Data sheet; effects of a pollutant on Daphnia.

YOU ARE WHAT YOU EAT

Overview: Students experiment with fat-soluble versus water-soluble dyes as models for contaminants.

Objective: To demonstrate how a chemical can bioaccumulate in an organism.

Materials for 28 Students: Red food coloring; red oil-based artist's paint; 500 ml mineral oil or baby oil; water; 23 baby food jars; 14 pipets; two large paper fish cut-outs.

Teaching Time: 45-60 minutes.

Note: This activity is planned for 28 students working in 7 groups of 4. It can be easily modified for more or fewer students.

Teacher Instructions

A. Background information:

Many of our present water pollution problems result from very small amounts of many different kinds of chemicals in water. Some of these chemicals are considered toxic because they are poisonous in very small amounts (parts per million, billion, or trillion). One part per million is one drop in a swimming pool. The toxic nature of a chemical is determined through a test called a toxicity test. The discharge of chemicals with high toxicity into fresh water is regulated so the amount of chemical does not exceed the amount that will harm organisms.

A relatively new water pollution concern is that some chemicals have a tendency to <u>bioaccumulate</u>. Bioaccumulation is the "building-up" of a chemical to a toxic level in an organism's body. The chemical may occur in the water in such minute amounts that the water is not harmful. However, when the chemical is taken in by organisms, they may not be able to excrete it, and it builds up in their bodies. When these organisms are eaten by others higher on the food chain, they pass on their toxic dose more concentrated than before. The term bioaccumulation is often used interchangeably with the term bioconcentration (accumulation from water only) and biomagnification (accumulation through the food chain).

A chemical is more likely to bioaccumulate if it is not very water soluble (meaning that it will not dissolve easily in water). If it is not water soluble, it is probably fat soluble (will dissolve in fat). Small amounts of chemicals that are water soluble, even if they are toxic, may be taken into the digestive system of an animal, dissolve, and pass out again in the wastes of that animal. Likewise, chemicals that are fat soluble will also be taken into the digestive system. However, fat-soluble chemicals are often stored in the animal's fat and will not pass out of the organism's body until the fat has been used up. This is the problem of bioaccumulation. The chemicals accumulate in an organism, which in turn is eaten by a bigger organism, which receives a greater dose of the harmful chemical. Bioaccumulation can be a difficult concept to understand. An excellent lesson to use with this demonstration is found in <u>WOW!: The Wonders of Wetlands</u>, "Marsh Mystery."

B. Before the lesson:

1. Put some oil (enough for about 10 drops for each group of students) in a jar. Add some oil-based artist paint (it comes in a tube as a thick paste; do not use acrylic paint) into the oil and stir it until it is smooth. Label this jar "chemical A." Put some water (enough for about 10 drops for each group) in a jar. Add several drops of food coloring. Label this jar "chemical B." Try to make the "chemicals" the same color and intensity.

2. If desired, photocopy the zooplankton drawing at the bottom of this page to make 14 small drawings (see student step 2).

3. Each group will require: paper towels, 2 pipets, 3 baby food jars, marker, and water. Since oil paint and food coloring can be messy, spread each station with towels, and have students wipe up spills immediately.

C. With the students:

1. Tell the students that our water supply has thousands of chemicals in it. Some of these chemicals are potentially dangerous to the plants and animals that live in the water and the animals that eat the plants and animals in the water. Near the base of the food chain are the primary consumers, also called zooplankton. Primary consumers eat plants and are eaten by other animals. Daphnia (a type of water flea) is an example of zooplankton. Today we are going to see how chemicals can affect these zooplankton and the other organisms that depend on zooplankton for food. Assemble groups of 4 students each.

2. First, have each group of students make 2 tiny (1") zooplankton pictures. These will serve as "labels" on the zooplankton models the students will be making. You can use a field guide to ponds (i.e., Pond Life) as a reference and have students draw them, make imaginary organisms, or simply cut out the zooplankton at the end of this lesson (Figure 3-2).

3. Give each group 3 baby food jars and have them put about 2 cm of water and 2 cm of oil in each container (1 cm = about 1 pinky width). Tape a picture of a zooplankton to each of the jars. Label one jar 1 and the other 2. Label the third empty jar "waste."

4. Tell the students that all living things are made up of water and fat (oil). The model that they have just made represents the fat and the water in the body of a zooplankton, and it will help us to understand how a chemical can bioaccumulate.

5. Show the students chemical A and chemical B. Explain that, for this lesson, they represent dangerous chemicals. Also explain that although they look the same, they do not act the same in the body of a living organism. Chemical B is considered highly toxic or dangerous to organisms. A toxicity test to assess this danger was run, and it was determined that 3 drops of chemical B will kill a zooplankton. Chemical A is not highly toxic. It was determined that 6 drops of chemical A will kill a zooplankton. There are equal amounts of chemical A and chemical B in the lake where our zooplankton live but not enough to harm them.

6. A zooplankton can get chemicals in its body by eating small plants that have the chemical in it or by taking it in from the water. Tell the students to carefully add two drops of chemical A to jar 1 using one pipet. Then using the other pipet, add two drops of chemical B to jar 2. Note: introduce chemical B below the line between the oil and water.

7. Gently swirl each of the jars and observe what happens (chemical A will mix with the oil and chemical B will mix with the water). Again, remind the students that although all chemicals can be dangerous to living organisms, there must be enough of the chemical there to harm it. In our experiment, two drops of either chemical is not enough to kill or harm the zooplankton.

8. Explain to the students that, in a living organism, water is constantly taken in and then expelled through its wastes. Fat (oil) is taken in and stored in the body. To model this, take a pipet and have each student carefully draw up the water (the lower layer) in each jar and put it into the "waste" jar. To have the zooplankton "drink," replace the liquid withdrawn with fresh water. Be sure to leave the oil layer in the jar. How many drops of chemical are in jar 1? (2) Put two marks on the zooplankton on jar 1. How many drops of chemical are in jar 2? (0) Don't put any marks on the zooplankton on jar 2.

9. Add another 2 drops of chemical A to jar 1 and another 2 drops of chemical B to jar 2. Remove and replace the water once again. How many drops of chemical are now in jar 1? (4) Put another 2 marks on the zooplankton on jar 1. How many drops of chemical are in jar 2? (0) Don't put any marks on the zooplankton on jar 2.

10. Explain that chemical A has collected in our zooplankton because chemical A is fat soluble (it will dissolve in oil). Chemicals that are fat soluble will bioaccumulate (build up in the fat of living organisms). In our demonstration, chemical A bioaccumulated in our zooplankton while chemical B kept passing out with the wastes of the organism.

11. Let's say there are now 4 drops of chemical A in our zooplankton, but this is still not enough to kill it. It takes 6 drops of chemical A to kill our zooplankton, but very few ever live long enough to collect 6 drops because they usually die or are eaten by the time it takes to accumulate 6 drops of chemical A. Why do we care if the chemical is in the zooplankton or not? It is not killing them or making them ill. The next step should reveal that this contamination could move up the food chain.

12. Let's say two fish swim along and eat 12 zooplankton each. Six of these zooplankton have 4 drops of chemical A in them. Collect 12 zooplankton for each fish, 6 jar 1's and 6 jar 2's - you may want to put the jars by or on a large paper cutout of a fish. How many drops of chemical A does each fish have in it? (24) Does it have any of chemical B in it? (no) Let's say it takes 35 drops of either chemical to make our fish sick and 40 drops to kill it. Do the fish look sick? (no)

13. Let's say a local fisherman catches these two fish and eats them for supper. How many drops of chemical A does he have in his body? (48) Let's say it takes 50 drops to make a human ill and 60 drops to kill him or her. What happens if this person eats too many fish?

14. Ask the students which chemical was more harmful: A or B? (A, because it dissolved in the oil, it was accumulated). Examples of fat-soluble chemical contaminants include PCBs, DDT, and dioxin. Following is a list of sources of chemicals that might bioaccumulate. Discuss this list with your class.

- Food we eat that has been sprayed with insecticide so it looks nice.
- Dairy products from cows whose hay and other food have been sprayed with herbicides.
- Careless handling of chemicals (pesticides, paints, petroleum products, etc.) so they find their way into our food/water supply.
- Eating fish from contaminated water. Pollutants could come from runoff from farms, lawns, and gardens as well as from industry.

15. Clean up: Wipe work stations and throw the towels. Jars should be wiped out and then washed. Plastic pipets may be permanently stained.

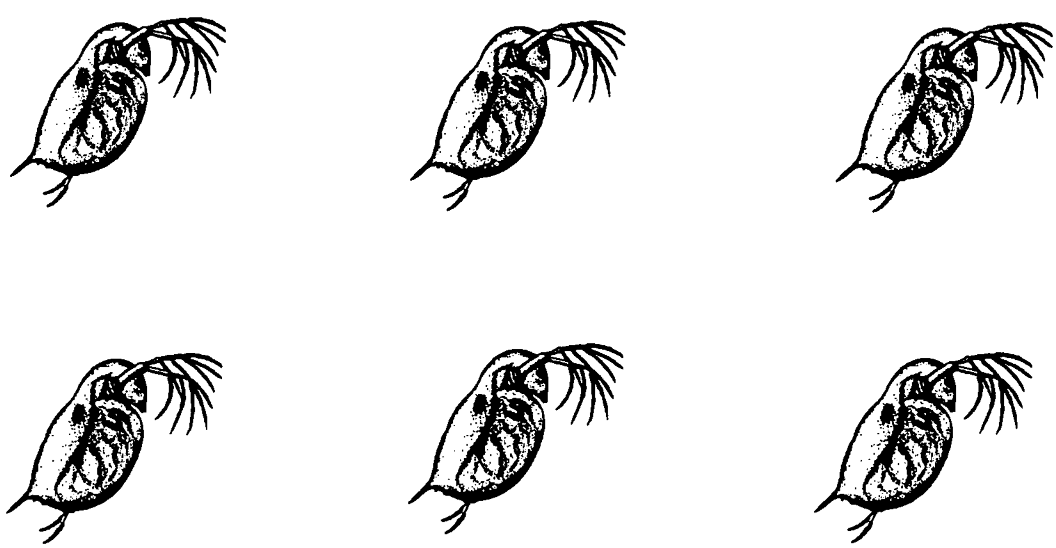


Figure 3-2. Zooplankton cut-outs.

Cool, Clear, Water?

Overview: Students experiment with "indicator fish" that have litmus paper fins.

Objectives: To demonstrate that pollution can be invisible. To discuss some types of pollutants, their causes/effects, and some solutions to pollution problems.

Materials for 28 Students: Three half-gallon or 2-liter sized glass or clear plastic jars; a half-gallon of muddy pond or river water; tap water; 1 Tbsp, or 10 ml, vinegar; 21 baby food jars; 21 plastic spoons; 21 narrow strips of litmus paper; picture of a lake or river; and 7 copies of the student comment sheet (Figure 3-3).

Teaching Time: 40-50 minutes.

Note: This activity is planned for 28 students working in 7 groups of 4. It can be easily modified for more or fewer students.

Teacher Instructions

A. Before the lesson:

1. Obtain neutral litmus paper from a chemical supply house. It is blue when immersed in a base and pink when immersed in an acid. Test the tap water and muddy water. For this experiment, they should both be basic, turning the litmus blue. If either one is acid, you can make it basic by putting in a pinch of baking soda. Blue litmus will designate water that is suitable for fish in this experiment.

2. Label the large jars 1, 2, and 3. Put muddy pond/river water into the jar #1. Put tap water in jar #2 and water with a small amount of vinegar in jar #3. The amount of vinegar you need depends on your litmus paper; add just enough to make the litmus turn pink. Designate pink as the color of litmus in "acid polluted" water.

B. With the students:

1. Work in groups of 4 students. Tell the students that we are pretending that the only water they get to drink today will come from these three jars. Each group should write on their comment sheets which jar(s) they would or would not drink from and why. Now have students label 3 baby food jars 1, 2, and 3. Distribute samples of the three waters to the appropriately marked student jars.

2. It is never safe to test unknown water for drinkability by tasting it. But sometimes animals can be used as "detectors" of pollution in water. We will not be using a real animal, but we will use an "indicator fish" that is very sensitive to acid in the water. Each group can now make 3 of these "indicator fish." Make each fish from a plastic spoon by taping one or more litmus paper fins to the convex bowl of the spoon. The handle of the spoon is the tail of the fish. Use permanent markers to draw eyes, gills, and mouth on the face of the fish. Label the fish 1-3.

3. Students can now immerse their 3 indicator fish into the appropriately marked water container, making sure the litmus fins contact the water. Students should record the results on their comment sheets.

4. Discuss the results. Students should have observed that the water in jar #3, although it appeared "normal", affected the litmus fins so they turned pink. If acidity was the only pollutant we were concerned about, our indicator fish with litmus fins would be good pollution detectors. Ask the students if they changed their minds about which jars of water they would choose as their drinking supply. Ask them to explain any changes of opinion on drinkability on their comment sheets.

5. Hold up a picture of a lake or a river. Ask the students if they think the water in the lake or river is safe to drink. Discussion should lead to the fact that you have no way of visually telling whether or not the water is safe to drink or safe for fish and wildlife.

6. In groups, have the students brainstorm an experiment which would tell us whether or not the water is safe to drink. Have each group share their experiment with the class to determine the safety of the water. Try to encourage the students to come up with creative solutions so they do not merely replicate the demonstration they observed in the three containers.

7. Using the chart (Table 3-1) as a source of information, discuss the different classes of water pollution, the effects and causes of the pollution, and possible solutions or treatments. You may also want to bring up the cost of treatment and contrast it to the cost of prevention. You may want the students to become "experts" on one type of pollution and then report to the class about that type. Also ask the students if they believe it is possible to make water "pollution free."

POLLUTION: Just because you can't see it doesn't mean it isn't there!

Name____________________________

At first sight, which of these jars would you be willing to have as your source of drinking water for the day?

At first sight, which of these jars would you NOT be willing to have as your source of drinking water for the day?

What happened to the litmus paper fins of the "fish" in jar #1?

Jar #2?

Jar #3?

After making observations, which of these containers would you now NOT be willing to have as your source of water for the day?

Our experiment for testing whether or not the water in the lake is safe to drink is:

____

____

____

____

____

Figure 3-3. Student comment sheet; cool, clear water.

Table 3-1. Water pollution and its effects on fish.

Types of Pollution	Effects	Causes	Prevention/Treatment
Thermal	- Death - Deformities of heart - Deformities of the yolk sac of young fish	- Waste heat from power generation - Clear cut of trees around the stream	- Cool water with cooling tower - Leave strip of trees growing along banks
Heavy Metals	- Death - Thick gills - Internal bleeding - Slowed growth	- Non-point sources - Point sources from industry & mining	- Treatment at a sewage plant - Industrial water treatment
Organic Pollution	- Death - Build-up in tissues - Retardation of development (due to lowered oxygen levels, etc.)	- Runoff from farms - Feed lots - Manufacturing wastes	- Treatment at a sewage plant - Prevent runoff from farms - Recycle batteries
Pesticides (a type of organic pollution)	- Death - Fused vertebrae - Build-up in tissue - Fin erosion	- Runoff from farms, lawns, golf courses, forests - Misuse of pesticides	- Prevent runoff from farms - Don't overuse on lawns and farms - Use when dry weather
Erosion	- Eggs of larvae on the bottom of river may be covered and smother - Decreased food production at base of the food chain - Undesirable species take over	- Road building - Forestry - Farming - Urban construction	- Improved land-use practices
Acid Rain	- Death - Fish stop eating - Reduced ability to reproduce - Kills immature fish	- Air pollution - Poorly buffered water	- Control industrial pollution - Burn less fossil fuels in cars, etc.

Pollution Munchers

Overview: Students compare the bacterial activity between sterilized and unsterilized "polluted" water. Bacteria from the unsterilized jar are then introduced to eat the "pollutant" in the sterilized jar.

Objective: To conduct an experiment that will demonstrate some aspects of bioremediation.

Materials: 2 drops octanol (capryl alcohol); 2 liters fish tank water; 2 coffee filters or 2 pieces of filter paper; 2 1-liter beakers; 2 glass stirring rods; funnel; Bunsen burner or hot plate; safety glasses; protective gloves.

Teaching Time: Approximately 40 min. of one class period then 5 min. daily for 2-3 days, 10-20 min. of another class period then 5 min. daily for another 2-3 days.

Note: This activity is partly demonstration, partly student activity.

Teacher Instructions

A. Background information:

Recent tests show that techniques using bacteria and other microorganisms to "eat" hazardous waste may be a promising solution for disposing of many organic wastes and cleaning up contaminated water. This approach is one form of "bioremediation." Bioremediation is the use of living organisms to clean up oil spills or remove other pollutants from soil, water, or wastewater.

Bacteria are microscopic organisms found in all domains of the planet. They are so small that about 200 bacteria will fit across the "thickness" of your thumb nail. All water bodies that support life have their own unique microscopic organisms living in them. A few kinds of bacteria cause diseases, but most of the bacteria in the water are helpful. Bacteria break down organic materials (materials made out of carbon) into smaller parts, which means they can decompose and recycle dead organisms and other materials in the water. Some can actually break down hazardous organic waste into harmless parts.

To use bioremediation at a site, we must first learn about the wastes in the site to see if they might be safely broken down by microorganisms. At many contaminated sites, microorganisms that break down organic wastes have naturally developed over time. Bioremediation generally starts by collecting and isolating these microorganisms to determine what nutrients and climatic conditions (like acidity, temperature, and oxygen levels) enhance their ability to break down the contaminant. Often, the microorganisms can then be transferred to other sites contaminated with the same wastes and stimulated to do the job there.

In this lesson, the students will use bacteria from fish tank water to demonstrate the concept of bioremediation. The bacteria will eat a non-dangerous "pollutant" and then be introduced to a sterilized area, where the "pollutant" also occurs, to see if they eat the pollutant in the new location.

The "pollutant" we will use is 1-octanol, also called capryl alcohol. It is a good model for us to use because it is safe for us to handle using normal precautions. The bacteria in our lake water can use octanol as food with no ill effects, and small amounts can be disposed of down the drain.

B. Before the lesson:

1. Obtain a very small amount of "1-octanol" from a chemical supply house such as *Sigma*. You need only 2 drops for this experiment, but you may have to buy more. It is very inexpensive. It is called <u>oct</u>anol because it is a chain of 8 carbons. The "ol" suffix is because it is a type of alcohol. It has a sweet smell.

2. Obtain two 1-liter beakers of water from a fish tank. Goldfish water is very effective. Label one beaker "A" and the other beaker "B."

   Safety note: Review chemical handling procedures and set out protective equipment. Use safety glasses, a lab coat or smock that is laundered after the experiment, and rubber gloves. Do not allow any experimental chemical to touch your skin or lips, and do not allow food around chemicals. The small amount of octanol this experiment requires is safe to handle in the classroom, but students should learn how to use protective equipment.

C. With the students:

1. Use the background information provided to introduce the topic of bacteria and their ability to break down organic materials, including some types of pollutants. Introduce octanol as a "pollutant" for the purpose of this experiment, and demonstrate the protective gear you use. Octanol is not actually a problem in the environment. Explain that we will use the octanol to "pollute" some fish tank water, and then see if there is any evidence that the existing bacteria can eat the octanol. If they do, we can then put these bacteria into sterilized fish tank water (without bacteria) to see if the introduced bacteria eat the octanol in the new location.

   Show the two beakers of fish tank water, and explain where you got them. Explain that each of these beakers has natural bacteria growing in it, but the bacteria are too small to see without a microscope. However, bacterial activity makes water cloudy or "cobwebby" so we can use these signs as evidence that bacteria are active.

   Safety note: The next step uses heat. Be sure that the container you use is safe for direct heating. Use hot pads or holders.

2. Put beaker "B" over a source of heat and boil it for 3 minutes. Immediately cover it and let it cool. Also sterilize a glass stirring rod in boiling water. When beaker B is cool, carefully lift the lid slightly, add 1 drop of octanol, stir with the sterilized rod, and cover tightly to prevent introducing new bacteria to beaker B. Also add 1 drop of octanol to beaker A and stir, but do not cover it so the bacteria have access to air. In our scenario, both beakers are now "polluted." Put the beakers aside in a warm place and observe daily. After 48 hours, the bacteria in beaker A should have multiplied so much that you can observe cobwebby bacterial growth or at least cloudiness. If there is no evidence of bacterial growth in 2 days, leave the experiment another day or two. If you leave it longer, you may observe bacterial growth in beaker B from accidental reintroduction of bacteria.

3. Discuss why beaker A shows bacterial growth (bacteria are breaking down the octanol) while beaker B is clear (there are no living bacteria there to break down the octanol). In our conceptual model of bioremediation, this is the case where naturally occurring bacteria have been discovered that can break down a pollutant. The next step would be to see if these helpful bacteria can be introduced to a polluted place where the bacteria do not occur (beaker B).

4. Using gloves, take beaker A and put the contents through a funnel lined with filter paper. Take out the filter paper and let it dry. Bacteria will be trapped on the filter paper. Bacteria are well adapted to surviving a dry period.

   Safety note: There is no reason to think that fish tank bacteria would be dangerous, however, it is good practice to observe good hygiene including keeping hands out of the experimental water and using gloves to handle the beakers.

5. When the filter paper is dry, cut out the center of it. Put the center of the filter paper into beaker B. Leave uncovered and observe for 2-4 days. If the introduced bacteria are breaking down the octanol, beaker B should become cloudy or cobwebby.

6. Explain once again that bioremediation makes use of naturally occurring or introduced microorganisms to break down contaminants. But before bacteria can be produced for this purpose, there must be many tests to make sure there will not be any dangerous consequences of their release into the environment.

7. Cleanup: The beakers may be emptied in the sink and washed in hot soapy water.

8. There are many enrichment possibilities for this activity. Bioremediation is a rapidly expanding field, so students should ask a media specialist for suggestions on finding more information on it.

Pea Soup Ponds

(Adapted from Lacustrine Lessons, 1984)

Overview: Students grow algae with different concentrations of fertilizer to see the effect of nutrients on algal growth.

Objective: To show how algae can become a problem if too much grows in a pond or lake.

Materials for 28 Students: 28 baby food jars; hot tap water that has been aged for one day; 7 eyedroppers; algal culture; commercially packaged plant fertilizer pellets or loose fertilizer (any type of commercial plant food may be substituted); artificial light source - preferably fluorescent; masking tape or wax pencils.

Teaching Time: 45-50 minutes one class period, 5-10 minutes during the next 4-5 class periods.

Note: This activity is planned for 28 students working in 7 groups of 4. It can be easily modified for more or fewer students.

Teacher Instructions

A. Background:

Algae are often called plants because they are green and do photosynthesis, but under most classification schemes, they are neither plants nor animals but are protists. When dissolved nutrients, such as nitrogen and phosphorus found in fertilizers and waste products, are added to a lake, algae can grow very quickly. The lake turns greenish, and the situation is called an algae "bloom." When the algae die in large numbers, which can be noticed by the presence of a strong odor, the real problems begin. As bacteria start to decompose the dead algae, oxygen is used up. This often leads to dangerously low concentrations of oxygen which is needed for the survival of other organisms such as fish. This happens even more rapidly in the winter, when the lake is covered with snow and ice, because the lake water is too dark for algae to produce much oxygen, and it is not in contact with air that could replenish its oxygen.

Algal blooms can greatly speed up "eutrophication", the natural aging process of the lake. Algal blooms can be controlled by preventing the release of excess nutrients into surface and groundwater. This can be achieved by pollution control regulations and by efficient sewage treatment facilities.

B. Before the lesson:

1. Order the algal culture ahead of time from a biology supplier (see Sources of Supplies at the end of this document). Make 7 copies of the algae growth chart (Figure 3-4).

2. Purchase fertilizer. It is simplest if all students use varying amounts of the same fertilizer. However, an extension of this lesson is to compare different types of fertilizers, such as liquid versus dry, "organic" versus synthetic, and fertilizers with different concentrations of nitrogen and phosphorus.

3. Prepare culture water by drawing 1 gallon of hot water from the tap and letting it stand for 1 day.

C. With the students:

1. Discuss algal blooms with the students, including common causes, referring to the provided background material. Explain that each group will have 4 identical jars of water and algae, and that their job will be to experiment to find the effect of fertilizer on algae. An important point that students may miss is that 1 of the 4 jars should be a "control," that is, it should be a reference against which the other jars can be compared. The control jar should have a concentration of zero, meaning no fertilizer should be added.

2. Break into groups of 4 students. Each student should have his/her own jar. Number each group.

3. Introduce the fertilizer to be used, and determine how it should be measured (for example, eyedroppers full for liquids, teaspoons for dry fertilizer, or numbers of pellets). Groups should plan their own experiments by selecting 4 different fertilizer concentrations (one being zero). Within the class, there should be a broad range of concentrations.

4. Label the jars with masking tape or wax pencils. Include the group number, student's name, and amount of fertilizer to be added. Have the students add fertilizer first, then fill with aged tap water to within a centimeter of the top.

5. Add one eyedropper full of algae to each sample jar. Leave jars uncovered.

   Safety note: Practice good hygiene and have students wash their hands after handling fertilizer or algae.

7. Place all jars in areas with similar light intensities. An artificial light source may be needed. Make sure the source of light is held constant for all jars. Dark at night is fine.

8. Have students observe their jars daily for any visual evidence of algal growth. Keep records on the algae growth charts or in experiment log books. After about three days, algae growth should become obvious as indicated by an increased "greenness" in the jars and possibly odor.

9. At the end of one week, have students fill out the "growth after 1 week" section of the algae growth chart. The members of each group should work together to decide how the algal growth in their control jar compares with their other jars. They may also record any other observations on their growth chart.

10. Discuss ways the data could be presented. One way would be to use water color paints or crayons to color in a square for each fertilizer concentration, showing that each concentration resulted in a different shade of green. There are many other options.

11. Have groups present their results. Did different groups have similar findings?

12. Ask if students observed any dead algae on the bottom of their jars. If yes, what will eventually happen to the algae? Would this be good or bad for animals living in the water?

13. Conclude by discussing with students why this excess of algae can be harmful to our lakes. Are there any practices students have seen that could contribute to this problem? Ideas include fertilizing lawns, fertilizing just before rainstorms, and throwing or sweeping organic matter like leaves or grass clippings in the lake. Are there actions students could take that would improve the situation? Some positive actions would be reducing or eliminating lawn fertilizer, using a different fertilizer (low phosphorus), or composting organic matter.

14. Clean up: The algal cultures should be poured on the ground, especially in areas that could use fertilizer. Avoid adding the cultures to surface water. If you pour them down the drain, they may burden your sewage treatment system.

16. Enrichment activities:

    - Compare different fertilizers.
    - Try varying temperature while keeping the nutrient concentration constant.
    - Visit a lake or pond to look for evidence of algal blooms.
    - Test the oxygen concentration of the water, before and after the algal blooms, with a water test kit.

Group:____________________

Fertilizer concentration	Day 1	Day 2	Day 3	Day 4	Day 5

Fertilizer Concentration	Growth Compared to Control Jar After 1 Week		
	Less	Same	More

Additional observations: color, odor, etc.

____

____

____

Figure 3-4. Algae growth chart.

Chapter 4
Collecting, Sampling, and Keeping Aquatic Organisms

Living organisms can be an exciting addition to any classroom - they fascinate students and give the room "atmosphere." Of course, plants and animals are also learning tools. However, many classrooms do not have living organisms in them because of time constraints, lack of knowledge, or lack of funds.

The following section contains ideas that will make organisms in the classroom a possibility for many teachers who never thought it could be achieved. Ideas include a variety of collection methods (for both teachers and students), how to maintain classroom cultures, and how to build inexpensive equipment for maintaining cultures.

AQUATIC SAMPLERS

(Adapted from Lacustrine Lessons, 1981)

Overview: Students make and use aquatic sampling gear.

Objective: To create useful aquatic sampling equipment from common, inexpensive items.

Materials for 28 Students: Preparation for sampling trip: 7 coffee cans (three-pound size); 7 plastic bleach bottles (one-gallon size); 4 pairs of old nylon stockings or pantyhose; 21 half-gallon milk cartons; 7 scissors; 7 small jars (such as baby food jars); about 140 feet of lightweight rope; string; 7 hammers and nails; 7 staplers; 7 weights (such as an 8 oz. fishing weight).

During Sampling Trip: 21 white plastic cups such as soft margarine cups; 7 notebooks; pens and pencils; 7 rulers; identification books such as Pond Life; 14 hand lenses; 14 forceps; 14 pipets or turkey basters; 7 sieves or pieces of window screen for sorting bottom samples; 7 white enamel pans or white plastic dishtubs; 14 plastic buckets; 1 small tarp or large piece of heavy plastic.

Teaching Time: 60 minutes to make equipment, at least 60 minutes for field trip, 45 minutes for classroom work.

Note: This activity is planned for 28 students working in 7 groups of 4. It may be easily modified for more or fewer students.

Teacher Instructions

A. Background information:

There are many interesting organisms to be found in the shallow water along a lake shore or pond. With the use of homemade sampling equipment, students can be introduced to a world of diversity in a small aquatic environment.

This lesson consists of two parts: 1) constructing aquatic sampling gear from common, inexpensive items, and 2) using the gear to explore shallow water. See the next section on active/passive collection methods for more ideas on sampling techniques. The sense of achievement gained by the students in making and successfully using their own equipment can be a valuable by-product of the lesson.

B. Before the lesson:

1. Ask the class to collect the materials listed above.

2. Make 7 copies of the instructions for making the equipment.

3. Select a sampling area that seems rich in life. There should be vegetation in the water - swimming beaches are not good for this activity.

   Safety note: Choose an area of lake shore or pond that has a gradual slope where the students can walk and wade safely. Be sure the site is free of poisonous plants, underwater drop-offs, broken glass, etc. Prepare permission slips for the field trip. Arrange for an extra adult for every 8 students for the sampling trip.

C. With the students:

1. The first part of this lesson is the construction of the equipment. Divide the class into groups of 4 each. Explain that each group will make sampling equipment from the items they collected. They will then use the samplers to collect aquatic organisms. Each group will make a nylon plankton net, a bottom scraper, and two or three observation chambers.

2. Give each group 2 copies of the instructions for making samplers. It will help the students a great deal if you have pre-made examples of the equipment.

3. Have one pair of students in each group make the plankton net and one pair make the bottom scraper. They can use the remaining time that they have to make the observation chambers. Give the groups 45-50 minutes to make their equipment.

4. Prepare the students for the sampling trip. It is very important that students dress appropriately by wearing jeans, with pant legs that can be rolled to the knee, or shorts, having a spare pair of shoes to wear in the water, and bringing a set of dry clothes, shoes, and a towel.

5. The next part of the lesson is the field trip. Warn students of possible hazards, and give directions for safe and respectful sampling.

   Safety note: Students should never sample barefooted. Define the boundaries the students are to work within. Students should stay in shallow water - less than knee deep; don't throw stones, no pushing, be respectful of animals captured.

6. Demonstrate the use of each piece of equipment. The bottom scraper should be tossed out using an underhand throw. It works best in soft mud or loose sand. Larger organisms can be found by filtering the contents through a sieve or piece of window screening and then turning out the contents of the sieve into a white enamel or plastic pan. Add enough water so organisms can float out, and pick them up with forceps and pipets or turkey basters. The organisms can be placed in margarine tubs with lids or in the plastic buckets for carrying.

7. The plankton net should be pulled through the water. If the bottom is soft, it can be carefully tossed out underhand and then pulled in. If the bottom is rocky, the jars might break. Pull the net through the water several times. Water will pass through the mesh of the nylon while small organisms will be trapped in the jar. Empty the jar into a margarine tub or plastic bucket for carrying. Do not use the plankton net in areas where it could become entangled in debris.

8. Explain to the class that they have an opportunity to examine the diversity of life in their sampling site. Give the groups 30 minutes to find as many different aquatic organisms (plants and animals) as they can find in their area.

9. Spread the groups out so there is 15-20 feet between each piece of equipment. Extra adults can watch for potential safety problems. Instruct each group to divide into pairs: one pair using the bottom scraper and one pair using the plankton net (later they can trade).

10. Have the groups keep examples of the different organisms in their observation chambers to show to the whole class later.

11. Remind the groups to carefully check the rocks, sticks, and large plant masses for small animals. They might want to rinse these items off in a sieve or piece of screen to find the organisms. Another technique is to lay wet wood and other objects on a tarp or large sheet of plastic. As the wood dries, organisms will become evident as they move about. Put organisms into a margarine tub or plastic bucket for carrying.

12. After 30 minutes, call the groups together and ask each of them to tell how many different plants and animals they found.

13. Compare the results. Did some find more than others? Was this due to any differences in location? Have some individuals describe or show some of the organisms found. Did everyone else find the same thing? Where was the organism found?

14. At this point, samples can be brought to the classroom in plastic buckets or returned to the water. Drawing and note taking can be done pondside but is much easier in the classroom. Provide Pond Life identification books (see Appendix B) for those who would like to identify their plants and animals.

15. Clean up: At the end of the activity, all organisms should be released into the water where they were found.

16. Summarize the sampling expedition. Point out that there were many small organisms to be found in an area that initially did not appear to be that rich in life forms. Remind them that different animals were found in different locations and habitats.

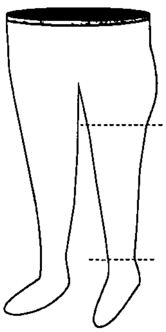
17. Conclude by pointing out that the diversity of species found in an area depends on a variety of factors. This could include temperature and light differences, availability of food, the variety of niches or habitats available, or even variations of water quality.

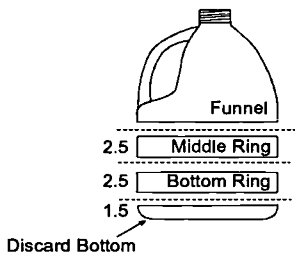
Nylon plankton net

Materials: Plastic bleach bottle, nylon stocking, 4 one-foot-long strings, small jar (e.g., baby food jar), scissors, light rope, small rubber bands, stapler.

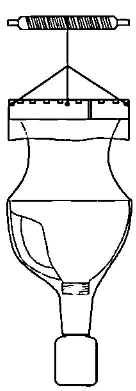
1. Using scissors, cut the bottom 1 inches out of a plastic bleach bottle and discard. Next, cut the plastic bleach bottle into three parts, creating a bottom ring and middle ring each 2 inches wide and a top portion that is shaped like a funnel.

2. Cut the stocking so that only the leg remains.





3. Bring the stocking leg through the bottom ring and then fold it over the outside. Cut the side of the middle ring, open it and place it over the bottom ring and nylon stocking. Securely fasten it in place using staples or glue. Puncture the sides of the rings in 4 places equidistant from each other. Loop and tie one string in each hole. Bring the other end of the 4 strips together and tie a knot.



4. Insert the funnel near the other end of the stocking. Fasten the stocking around the mouth of the funnel using small rubber bands. Remember to leave about five inches of stocking loose at the bottom end.

5. Fasten the loose end of the nylon stocking to the mouth of the small jar using small rubber bands.

6. Attach the rope to the knotted strings to form a towline for the constructed plankton net. A small weight may be attached to the towline if necessary.

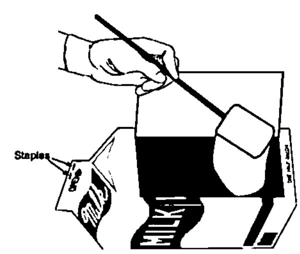
Observation chambers

Materials: half-gallon milk cartons, scissors, stapler.

1. Staple the pouring spout closed.

2. To make a chamber with a hinged lid - cut three sides of the carton wall which is on the same side as the stapled pouring spout (see diagram). This type of chamber is good for holding light-sensitive animals.

3. An open-top chamber can also be made - simply cut all four sides of the carton wall on the same side as the stapled spout, and remove the carton wall.



Bottom scraper

Materials: coffee can, hammer, nail, light rope.

1. Punch out 15 holes in the bottom of the can, using a hammer and a nail. Punch one hole on each side of the can near the top directly across from each other.

2. Tie a weight (an 8 oz. fishing weight works well) to loop in a piece of line that is tied tightly between the holes near the top of the can.

3. Tie the tow rope to the same loop as the weight, and the bottom sampler is ready to use.

Figure 4-1. Equipment construction for water samplers.

Active/Passive Collection Methods

Overview: This is a teacher preparation activity.

Objective: To give teachers a variety of methods to use when collecting freshwater specimens for the classroom.

Materials: Vary from method to method.

Preparation Time: Varies.

Teacher Instructions

A. Background information:

Some of the activities in this packet call for the use of live organisms. It has been suggested that you purchase these organisms from a biological supply company. Another possibility for getting live organisms for these activities, and others you may wish to conduct, is to keep a "farm" of these tiny organisms in your classroom. You can collect the animals for your farm from a nearby pond, stream, or lake. The following information deals with various collection methods. You can try several of these and adapt them to best suit your situation. Different methods, at different times of the year, will give you different organisms.

There are two different kinds of collection methods: active and passive. Active collection methods deal with going out and collecting the organisms on the spot. Passive collection deals with placing some sort of apparatus in the water to which the organisms will attach. After a period of time, you collect the apparatus. These methods can be carried out by one person, small groups, or an entire class. Passive collection would be a better choice if you don't have a large source of water around or if your source is far away.

B. Collection and viewing equipment:

Following are inexpensive items that are useful in the field:

- 5-gallon plastic pails, used to carry water and materials
- pyrex or metal trays, such as cake pans, for picking through debris
- magnifiers, used for close examination
- jars, such as canning, salad dressing, peanut butter, etc. with covers
  (If you wrap the jars with one or two circles of tape, there is less danger of the jars shattering if they are knocked together or dropped. Clear plastic peanut butter jars work very well.)
- nylon strapping tape to reinforce pails if necessary
- smaller pails
- funnels to fill sample jars

- thermometer for field information
- marker (to write on glass)
- rubber boots, hip boots, or waders

C. Specialized collection methods and equipment:

Following are methods used in aquatic sampling, along with more specialized equipment you can make:

Active Sampling methods and Equipment:

1. Kick method. This is used in streams. Kick or agitate a rock while holding a net down stream.

2. Rock or debris picking. This is used in streams or ponds. Pick up a rock or debris and search for attached animals. Large, flat rocks work best. Alternatively, place the debris on a plastic sheet by the shore and wait for animals to begin wriggling so they can be seen.

3. Netting. Used in streams or ponds. Use a fine meshed net to sweep animals directly out of the water. An aquarium net works well. You can also make a simple net by using a wood stapler to attach a 2' x 2' piece of window screen to two 3' long 2" x 2" wood pieces. The wood pieces, on opposite sides of the screen, form handles. This net can be rolled up for easy storage.

4. Dipping. Used best in ponds or slow streams. Use a cup attached to an extended handle, like an old fashioned water dipper.

Passive Sampling methods and Equipment:

1. Stacked plates. Used in streams or ponds. Obtain several square masonite boards of decreasing sizes. The largest should be about 4" on a side. Drill a hole in the center of each of the boards. Place a bolt through the center and stack the boards smallest at the top, largest at the bottom. Separate each board with up to 4 washers - different sized spaces attract different organisms. Put a nut on the top of the bolt to hold the boards in place. Anchor the apparatus to the bottom of the stream or pond with a stake and a nylon string. Animals will seek out the spaces in the board or colonize the board surface. Leave it in the water for a few weeks. After collection, remove the bolt and scrape the plate surfaces into white pans, with a little water in them, so you can pick out the organisms.

2. Nylon bag filled with leaves. Used in streams or ponds. Fill a mesh bag (such as an onion bag) with leaves. Anchor it to the bottom of the stream or pond. Check after 2 weeks by picking up the bag and swishing it in a pan of water to see what organisms have colonized it. It can be replaced and checked later or opened and carefully picked through.

3. Sponge. Used in ponds or streams. Anchor a kitchen sponge to the bottom of the pond. Small organisms will crawl into the pores of the sponge. Squeeze the water out of the

sponge, catching it in a white margarine tub, when ready to view.

4. Drift net. Used in streams. The drift net will collect animals in a stream that are drifting along the water's surface and beneath it. You can make one by attaching fine mesh netting to a sturdy frame. One side of the frame will sit on the bottom of the stream with part of the net and frame above the surface of the water. Anchor the frame to the stream bed. Many insects drift along the surface of the stream in the evening hours so this net is most useful when left out overnight or collected in the late evening.

5. Plastic strips. Used in streams or ponds. Cut a strip of heavy plastic into 1-inch strips about 3 feet long. Anchor the strip to the bottom of the stream and check after 2 weeks.

6. Rope. Used in streams. Anchor a thick piece of rope to the bottom of the stream and check after 2 weeks.

7. Bricks. Used in streams. Place red, three-holed bricks on the bottom of the stream and check after 2 weeks.

8. BBQ cage. Used in streams. Fill a metal cage from a rotisserie with rocks. Anchor it to the bottom of the stream. Pull the whole works up every 2 weeks and examine the rocks.

D. Sampling tips:

- Take a sample of the water from your collection site with you. If you choose to keep some specimens, they will be adapted to this water.
- Be careful not to over collect or to disturb the shoreline habitat.
- Make sure, while you are out in the field, that specimens you collect do not heat up. An increase in temperature of greater than 10 degrees may kill the organisms. Cooling the organisms, as in a cooler with ice, is generally acceptable.
- Do not put specimens in water straight from the tap. Tap water may have chemicals in it which will kill your specimen. If you need to use tap water, you should use hot tap water and allow it to stand over night. You can also purchase chemicals from a pet store that will dechlorinate water.
- Have a pond/stream field guide (see Reference Section) on hand to identify unknown specimens.
- Quickly return specimens to the water whenever possible.
- Remind students to treat the pond/stream/lake, and the organisms found in and around it, with respect and with a sense of responsibility.
- Organisms that you collect from a stream need flowing water so your aquarium should be well aerated.
- Pond animals are generally easier to keep in classrooms than stream animals.

Making a Classroom Aquarium

(Adapted from Project WILD - Aquatic, 1992)

Overview: This is a teacher preparation activity.

Objective: To provide a method for making a classroom aquarium from inexpensive materials.

Materials: 5 pieces of glass; aquarium sealant.

Preparation Time: 1-2 hours after assembling materials.

Teacher Instructions

A. Background information:

You can make an inexpensive aquarium to hold fish, or any other organisms, in your classroom. If you have never had an aquarium in your classroom, a five- to ten-gallon tank (19 to 38 liters) is recommended as a beginning size; however, this size will hold only a few fish. Normal window-grade glass is suitable for five-gallon tanks, but bigger tanks should be made from heavier (thicker) glass.

B. Materials:

1. Obtain glass from a glass shop. They will cut the pieces from glass of the weight you desire. Five pieces of glass are needed (Figure 4-2); one for the BOTTOM, two for each SIDE, and two for each END. The width of the END pieces will have to be narrower than the width of the BOTTOM piece by two times the thickness of the SIDE pieces. These specifications are necessary to assure that the ENDS and SIDES all fit inside the perimeter of the BOTTOM. Have the glass shop polish all the edges of the glass pieces on their machines so that they are smooth and square. Ask them not to bevel the polished edges.

2. Purchase aquarium sealant from an aquarium supply shop. Aquarium sealant is a high-quality glue for sticking pieces of glass together. <u>Do not</u> use ordinary silicone sealant for this - it contains a compound that is toxic to fish and other animals. The tube will say "aquarium sealant" on it. Avoid contact between sealant and clothing.

3. Squeeze a wide line of sealant out of the tube around the inside perimeter of the piece of glass to be used for the BOTTOM of the tank (Figure 4-2). Next, prepare one END and one SIDE piece. Squeeze a line of sealant around the outside perimeter of 3 sides of the END piece. On the SIDE, squeeze a line of sealant along the outside edge of the bottom and just inside of the edge along each end.

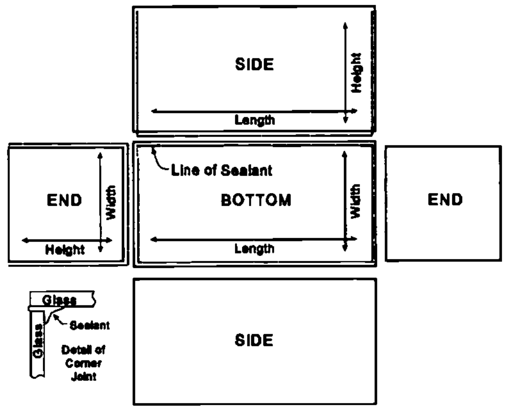


Figure 4-2. Schematic of aquarium construction.

4. Stand the END and SIDE pieces on top of the BOTTOM piece. Refer to sealant instructions for guidance on how long support should be provided to newly bonded pieces. The edge of the SIDE piece should overlap the edge of the END piece at the corner as shown below. Repeat this process with the other END and SIDE pieces.

5. The tank will now be formed. Make sure the ENDS and SIDES are square at the corners and perpendicular to the BOTTOM. Remove excessive amounts of sealant. Leave the tank where it was assembled until the sealant dries. It always stays somewhat rubbery. This drying process will take about 24 hours (refer to sealant instructions).

6. After the tank has dried, spread another line of sealant along all the interior seams of the tank (i.e., where SIDES and ENDS meet and where SIDES and ENDS meet the BOTTOM).

7. Fill your new tank with water to test that it is secure and leak proof.

   Safety note: Water is heavy! It is never a good idea to try to carry even a small aquarium while it is filled with water.

Raising Algae and Water Fleas

(Adapted from Lacustrine Lessons, 1983)

Overview: This is a teacher preparation activity.

Objective: To explain methods to raise and keep algae and water fleas (Daphnia) in the classroom.

Materials: Aquarium; air pump and tubing; air stone; aquarium heater if the room is cool; large glass jars; gold fish; pond water; aged tap water.

Preparation Time: Varies.

Teacher Instructions

A. Background information:

Daphnia (water fleas) are filter-feeding animals that consume algae. They collect algae on the fine setae (hairlike structures) of their filtering legs. They can easily be kept alive in the classroom or laboratory for extended periods of time as long as they receive an adequate supply of fresh water and algae.

The most important considerations in keeping algal cultures healthy are to supply an adequate amount of nutrients and light, and to harvest the culture regularly so that it doesn't become overcrowded. There are many complex methods described for maintaining pure, bacteria-free, single-species cultures of algae. However, Daphnia seem just as happy when supplied with a mixed algal culture and may even benefit from the bacteria and the protozoans that may be present.

The following culture method will allow you to keep both unicellular algae and Daphnia alive with minimal effort. Occasionally, a culture will crash (die off) for some unknown reason. In that case, you can get a new culture started from your nearest pond, biological supply house, University, or EPA lab and try again.

B. Algae Culture

1. Set a five-gallon (or larger) aquarium on a well-lighted window ledge, or attach an aquarium light and timer set to give at least 10 hours of light each day. You will need a small air pump and air stone to keep the water circulating. If the room drops below 68 degrees Fahrenheit (F), add an aquarium heater. The system works best at 72-78 degrees F.

2. Fill the tank at least three-fourths full with hot tap water. Chlorine may harm your culture. If your water is chlorinated, or if you are not sure if it is or not, age the water by allowing it to sit for a day or two to allow the chlorine to vaporize.

3. Start the algal culture by introducing an inoculum (starter set) into the tank. Sources of inoculum would be a few milliliters of very green water from someone else's algal culture or about a gallon of pond water. Let the tank sit for a day or two so that the algae can become established. Now add a few guppies or goldfish. Feed the fish regular fish food daily. The fish provide nutrients for the algae (in the form of fecal material) and consume any zooplankton that may have been in the pond water.

4. You should have a tank of greenish water in a week. You should remove about one-fifth of the water each week or so and add aged tap or pond water so that the algae don't become over crowded. If the water starts to clear up, add fresh inoculum, decrease the amount of water removed each week, or increase the amount of light provided.

5. The bottom of the tank should be siphoned every three to four months (more often if you tend to overfeed the fish).

C. Water Flea Culture

1. Fill two or three one-gallon (or larger) jars with tap water. Large glass salad dressing jars from restaurants work well. Let the water sit for a few days.

2. Now add green water from the algal culture until the mixed water has a light green tint. Add a few water fleas (Daphnia) to each jar. Obtain them from someone else's culture, a supply house, or collect plankton from a pond or lake using a fine mesh net.

3. The animals should begin eating the algae and reproducing regularly. When the culture gets crowded, remove some of the water fleas to use for experiments or feed them to your fish.

4. The water fleas may be captured using a fine-screened dip net. Some may be injured if the dipping is too forceful. Both living and dead water fleas are excellent fish food.

5. Water fleas may also be captured alive by using a siphon tube to capture individual animals. This technique results in fewer injured water fleas and is probably a better method for getting animals to use for experiments. Simply place a finger over one end of the siphon tube and put the open end of the tube near a water flea. When your finger is briefly lifted up, water and the water flea will be drawn into the tube. Place your finger back over the tube and transfer the water flea to another container. A plastic pipet with a wide opening or a turkey baster will also work for transferring Daphnia.

6. To keep your water flea culture healthy, add fresh algae to the jars about once a week.

7. Every two or three weeks, the cultures should be thinned out to avoid over-crowding. To thin out the culture, you should pour half of the water flea culture into a clean, empty jar and fill it with aged tap water. The remaining portion of the culture will include some dead animals along the bottom. Use this part of the culture to feed your fish or just dispose of the animals. Then rinse out the old culture jar and save it for the next thinning process.

8. A final reminder: these cultures do periodically "crash" (die), even for experts. Keeping two or three culture jars going can help you avoid losing your whole water flea supply. Never put the cultures in direct sunlight.

References

Environment on File. 1991. The Diagram Group, Facts on File, Inc., New York, N.Y. 10016.

Lacustrine Lessons. 1981. Minnesota Seagrant Extension Program. Duluth, MN 55812.

Lacustrine Lessons. 1984. Minnesota Seagrant Extension Program, Duluth, MN 55812.

Project Stewardship Minnesota. State of Minnesota. Environmental Education Advisory Board, St. Paul, MN 55155.

Project WILD - Aquatic. 1992. Western Regional Environmental Education Council, Inc., Bethesda, MD, [Reprinted (or adopted) with permission from Project WILD].

Appendix A
Glossary of Terms

Bog: A wetland where low oxygen levels and soil temperature cause incomplete decomposition and limited drainage that results in an accumulation of fibrous peat.

Daphnia: The genus of a large number of common species of small crustaceans commonly called water fleas.

Ecosystem: An ecological community, together with its physical environment, considered as a unit.

Environment: The sum of all external conditions and influences affecting the development and life of organisms.

Food Chain: An arrangement of the organisms in an ecological community according to the order an organism consumes another organism in which each uses the next (usually lowest) member as a food source.

Fresh water: Clean, unpolluted water without salinity.

Groundwater: The supply of fresh water found beneath the earth's surface (usually in aquifers); often used to supply drinking water to wells and springs.

Nonpoint source Pollution: Pollution that cannot be traced to a specific origin or starting point, but seems to flow from many different sources.

Nymph: An aquatic stage of development of some kinds of invertebrates.

pH: A measure between 0 and 14 that indicates the relative acidity (pH less than 7) or alkalinity (pH greater than 7) of a substance.

Plankton: Minute animal and plant life in a body of water.

Pollutants: Solid, liquid or gaseous substances that contaminate the local or general environment.

Predator: An animal that eats another animal.

Prey: An animal that is eaten by another animal.

Toxicity: A response either immediate (acute) or longer term (chronic) that changes an organism's ability to function normally.

Watershed: A region or area that may contain several rivers, streams or lakes that ultimately drain to a particular watercourse or body of water.

Wetlands: Land or areas, such as tidal flats or swamps, that are often or periodically saturated with water.

Appendix B
Additional Resources

Books

Pond Life, 1987, by George K. Reid. Golden Press, N.Y.

Wetlands, 1988, by William Niering. Alfred A. Knopf Publishers, Audubon Society Nature Guide Series.

Journals

Earth Day Every Day, 1993, U.S. EPA Office of Water, Teacher's kit, Reference #EPA 800-B-93-004.

EPA Journal, Office of Communication and Public Affairs, Superintendent of Documents, GPO, Washington, DC 20402.

Hands On / Minds On: Science Activities for Children, 1990, American Indian Science and Engineering Society, 1085 14th Street, Suite 1506, Boulder, CO 80302-7309.

Science Activities, (magazine) Heldref Publications, 1319 18th Street NW, Washington, DC 20036. (1-800-365-9753).

Publications

WOW!: The Wonders of Wetlands, 1993, Environmental Concern, Inc., P.O. Box P, St. Michael, MD 21663. (410-745-9620).

SUPPLIES AND EQUIPMENT

Carolina Biological Supply, 1-800-334-5551.

Delta Education, 1-800-442-5444.

Sigma Chemical Co., 1-800-325-3010.

LaMotte Chemical Products Co., P.O. Box 329, Chestertown, MD 2120.

ERIC

Accounts Receivable Aging as of

31-Mar-03

Org	Fund	Acct	Program	Acct.Bal. 3/31/03	0-30 Days	31-60 days	61-90 days	91-120 Days	Over 120 Days
12753	110037	13010		25341.84					
12753	110037	13020		158.14					
12753	110037	13030		6.36					
12573	110037	13410		-3,718.90					

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